

Changes of China Energy Consumption in Past Decade and Trend in Future

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Abstract

China's total energy consumption in 2011 has reached 3.48 billion tons of energy coal, which took about 20% of the whole world's consumption. As the main energy form in China the coal took a proportion of about 68-71% of the primary energy. The industry consumed about 70% energy in the national total amount, in which the chemical engineering, building materials, steel and iron, and power generation consumed 55-60% in the whole industry. On the other hand, for most high energy-consumed products in China, the energy consumption per capita has been found declining gradually in the past decade and is approaching the advanced level in the world. The efficiency of the energy usage shows a steady improvement. With the energy structure change of the world in the 21st century, China is supposed to make great effort to adjust the layout of its energy production as well as the consumption. A new framework of energy production and consumption will form in China, in which the fossil energy and the renewable energy such as wind, solar, biomass, geothermal forms may be of the same significance.

Keywords

Energy Consumption; Energy Structure; Energy Per Capita; Energy Efficiency; Renewable Energy

Introduction

With the rapid development of economy in the new century, all countries around the world begin to pay more attention to the energy problem. At present the primary energy structure in the world still consists mainly of coal, petroleum, and natural gas. Many problems have arisen due to the attribute of these non-renewable fossil fuels, which involves the inefficient utilization of energy and the highly imbalance between the energy supply and its demand. In addition, ever escalating energy consumption has also led to serious environmental problems. The statistic data revealed that about 65% of greenhouse gas emissions came from the energy consumption, and those greenhouse gases have caused the disasters such

as the global warming, polar ice melting, tsunamis etc. These permanent damages to the humankind have pushed people into deep and wide thinking. As one of the important emerging economy states in the world, China faces huge challenges for keeping the high growth rate of the economy in the upcoming decades. The appropriate energy policy is the premise condition to guarantee the economy in a healthy development track. For this purpose, it is necessary to know the change of our country's energy consumption, and the possible trend and pattern in the future.

Changes of China's Energy Consumption over the Past Decade

Like most other countries in the world, China's energy consumption has been increasing year by year in the past decade. In 2011 China's total energy consumption had reached 3.48 billion tons of energy coal, which is 2.4 times of total energy consumption in 2000. Figure 1 shows the growth trend of China's total energy consumption in the past ten years. The data in the figure are from China Energy Statistical Yearbook 2011, and The Joint Statistical Manual of the BRIC countries, 2012. The pattern of steady increment of the consumption amount is obviously, and there is no sign of slowing down in the near future.

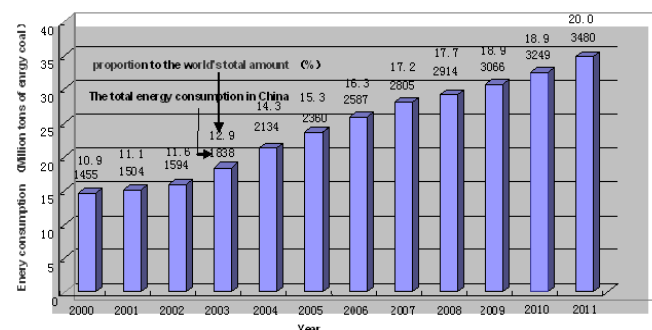


FIG. 1 DECADE CHANGE OF CHINA'S TOTAL ENERGY CONSUMPTION

The total energy consumption is defined as the sum of the various energy forms consumed by the industry and the civil in a period of time. It is the general

TABLE 1 CHANGES OF CHINA'S ENERGY CONSTITUTION IN THE PAST TEN YEARS

Years	The percentage in the total energy consumption (%)					
	coal	oil	natural gas	Hydro-power	nuclear power	renewable energy
2000	69.20	22.20	2.20	5.93	0.44	0.03
2001	68.30	21.80	2.40	7.08	0.44	0.00
2002	68.00	22.30	2.40	6.76	0.54	0.00
2003	69.80	21.20	2.50	5.65	0.84	0.01
2004	69.50	21.30	2.50	5.91	0.83	0.00
2005	70.80	19.80	2.60	5.91	0.79	0.10
2006	71.10	19.30	2.90	5.90	0.74	0.06
2007	71.10	18.80	3.30	5.94	0.76	0.10
2008	70.30	18.30	3.70	6.68	0.78	0.24
2009	70.40	17.90	3.90	6.50	0.80	0.50
2010	68.00	19.00	4.40	6.71	0.89	1.00

Note: In the table, the hydropower and the nuclear power have been converted into the energy coal with the conversion factor of 10⁴ kWh_e= 1.229 ton of energy coal. Data source: China Energy Statistical Yearbook 2011.

indicator that presents the energy consumption level and the growth rate. The total energy consumption includes the coal, the crude oil and its products, the natural gas, the electricity, and the renewable energy. Changes of China's energy constitution in the past ten years are shown in Table 1. One can see that the percentage of the coal and the hydropower is approximately stable, the oil declines slightly, the natural gas increases steadily, and the nuclear power and the renewable energy stay ever in a very low proportion. The coal and the oil are still the main source of energy in China, which two forms take roughly 90% of the total energy consumption.

TABLE 2 WORLD'S ENERGY CONSUMPTION FROM 2000 TO 2011 (mt energy coal)

year	2000	2001	2002
Total energy consumption	13403.4	13522.3	13788.3
year	2003	2004	2005
Total energy consumption	14282.6	14974.3	15429.9
year	2006	2007	2008
Total energy consumption	15839.7	16283.4	16479.7
year	2009	2010	2011
Total energy consumption	16233.1	17146.3	17400.0

Data source: BP World Energy Statistics Yearbook ,2011

To facilitate the comparison, the change of the world's total energy consumption in the past 10 years is listed

in Table 2. The corresponding proportion of China's total energy consumption over the world's total is presented in Figure 1. After the eleven years the China's total energy consumption increased by 139%, while the world's total increased only 29.8%. Due to its high growth rate, the China's energy consumption and supply are reforming the pattern of world energy. On the other hand, in China's energy supply and consumption there exists intrinsic unmatchable problems. Figure 2 shows the constitution of the world's energy consumption in 2010. The oil and the natural gas took 34% and 24% respectively in the world's total, in contrast the proportion of coal in China's primary energy consumption was around 70%. In addition, the supply and the consumption of the oil in China were highly unmatched. In 2007, China's oil consumption accounted for 18.8% of the national total energy, while the oil production accounted for only 12.6%, one third of the oil supply was dependent on

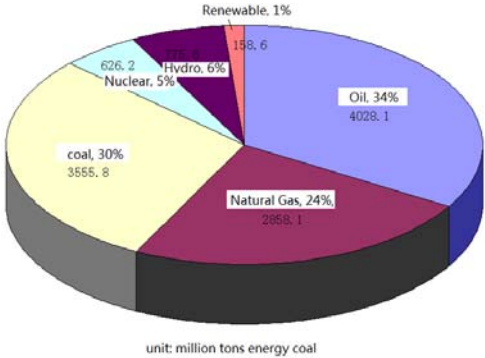


FIG. 2 THE CONSTITUTION OF THE WORLD'S ENERGY CONSUMPTION IN 2010 , BY THE DATA OF BP WORLD ENERGY STATISTICS YEARBOOK ,2011

TABLE 3 THE ENERGY CONSUMPTION OF SUB-DEPARTMENT IN CHINA

Year	Industry (%)	Civil (%)	Transportation (%)	Agriculture (%)	Others (%)	Total energy consumption (Mt ec)
2001	68.5	11.4	7.6	4.6	7.9	15.04
2002	68.9	11.5	7.5	4.4	7.7	15.94
2003	70.0	11.3	7.4	3.9	7.4	18.38
2004	70.5	10.5	7.4	3.8	7.8	21.34
2005	70.8	10.5	7.5	3.5	7.7	23.60
2006	71.2	10.3	7.5	3.4	7.6	25.87
2007	71.6	10.1	7.8	3.1	7.5	28.05
2008	71.8	10.9	7.9	2.1	7.3	29.14
2009	71.5	11.1	7.7	2.0	7.7	30.66
2010	71.1	10.7	8.0	2.0	8.2	32.49

import from abroad. With the popularity of private car into more and more Chinese family, the import ratio of the oil may increase continually in the upcoming years. In most developed countries, oil is always the mostly consumed energy. In the US, oil accounts for 40.7% in its total energy consumption. The over-consumed coal energy is a main causation of the heavy pollution in the environment in China. Reducing the coal proportion, and promoting other energy forms of less emission, is an important problem for Chinese government to deal with in the new century.

As for the other energy forms apart from the coal, the proportion of the natural gas and the nuclear energy in China's energy consumption is much lower as compared with the world's average level, while the hydropower is in the comparable state. Quite a few nuclear power stations have been or are being constructed in recent years in China, but the output of the nuclear facilities remains still less than 1%, which contrasts to the average level of 6% of the world. What is appreciated is the steady development of the renewable energy in China in recent years. With the support of the national oriented policy, the renewable energy, including the solar, the wind, and the geothermal etc, has begun to play more important role in some regions. As listed in Table 1, the percentage of renewable energy had reached 1% of the total energy consumption, which is already comparable to the average level of the world today.

Energy Consumption in Subdivision

Statistic Data of the Energy Consumption in Different Departments

The annual statistic data of the energy consumption for different departments from 2001 to 2009 are presented in Table 3. The data are copied from the China Energy Statistical Yearbook that was published in 2010.

Form Table 3 one can see that the energy consumed by the industry accounts for about 70% of the national total, the civil and the transportation are in the second and third position. To draw up the national policy of energy conservation we must know how and where those massive energies flow and which are the mostly energy-consumed industrial branches. Statistics Report on the National Economic and Social Development 2010 issued by the Chinese government affirmed six highly energy-consuming industries: chemical engineering (raw materials and products of chemistry), building materials (non-metallic mineral products), iron and steel (ferrous metal smelting and rolling process), the electric power generation (electricity and heat production and supply), non-ferrous metal smelting and rolling process, and oil and nuclear fuel processing industry. Among those the leading energy-consuming branches are the chemical engineering, the building materials, the iron and steel, and the electric power generation, which four branches account for about 55 ~ 60% of the total energy consumed by the industry. The energy consumption by the four branches in 2000 and 2010 is listed in Table 4. What they consumed in 2010 was 2.35 times of that in 2000, and their proportion in the national total energy consumption was over 40%.

TABLE 4 TEN YEAR'S CHANGE OF THE ENERGY AMOUNT CONSUMED BY THE FOUR LEADING ENERGY-CONSUMING INDUSTRIES IN CHINA (mt energy coal)

year	2000	2010
chemical engineering	143.3	296.9
building materials	137.7	276.8
iron and steel	189.6	575.3
electricity and heat generation	120.3	242.1
sum amount by the four branches	590.9	1391.1
percentage in national total	40.6%	42.8%

TABLE 5 TEN YEAR'S CHANGE OF ENERGY CONSUMPTION BY STEEL AND IRON INDUSTRY IN CHINA

year	fully energy consumption (kgce/ton steel)	comparable energy consumption (kgce/ton steel)	total energy consumption by steel & iron industry and percentage in the national total (Mt energy coal)
2000	885	760	110.2 (7.6%)
2001	876	870	117.2 (7.8%)
2002	803	715	123.4 (7.7%)
2003	792	696	134.1 (7.3%)
2004	765.40	755.29	162.0 (7.6%)
2005	741.05	714.12	182.4 (7.7%)
2006	645.12	623.04	197.8 (7.6%)
2007	632.12	614.61	225.8 (8.1%)
2008	629.93	609.61	223.2 (7.7%)
2009	619.43	595.38	238.2 (7.8%)
2010	608.44	588.39	260.5 (8.0%)

Energy Consumption by Iron and Steel, Cement, and Non-ferrous Metallurgical Industry

1) Iron and Steel

Iron and steel industry is the number one of energy consumption in all industrial branches. In recent years, with the technology innovation and the improvement of the equipment, iron and steel industry have greatly decreased the energy consumption level, and is approaching to the international advanced level. Table 5 presents the ten year's change of the average energy consumption for the steel and iron companies in China (Wang T. C. et al, 2007; Wang W X, 2010). The fully energy consumption per capita steel production had dropped from 885kgce/t in 2000 to 608.44kgce/t in 2010, and the comparable energy consumption per capita steel had dropped from 760kgce/t to 588.39kgce/t. Nevertheless, though the energy consumption per capita steel declined, the total energy consumption by the national iron and steel industry was increasing year by year. The total energy consumption in 2010 is 2.36 times as much as in 2000. The annual energy consumption and the corresponding proportion in the national total are listed in the last column of Table 5.

2) Cement

In the new century, the rapid development of the China's cement industry attracted the worldwide attention. In 2011, China's cement output reached 2.09 billion tons, accounting for 56% of the total cement production of the world, and ranking first in the world all the time in the past 26 years. According to the data released by the Union of Supervising Quantity and Economy in China's

Building Materials Industry in 2011, the cement branch consumed 150 million tons of energy coal in 2009, accounting for 72.4% of the total energy consumption of the whole building material industry. Compared to the developed countries in the world, the Chinese cement industry is still backward in all aspects of the energy consumption by output, by capita production, or by working procedure. Table 6 shows the ten year's change of the energy consumption by the cement industry (Jiang M. L., 2007; Zeng X. M., 2011). The annual total energy consumption by the cement branch and the corresponding proportion in the national total is listed in the last column of Table 6. In 2010, the fully energy consumption per ton clinker already dropped to 115 kgce/t, which is 26.8% lower in comparison with the data of 2001.

TABLE 6 TEN YEAR'S CHANGE OF ENERGY CONSUMPTION BY CEMENT INDUSTRY IN CHINA

Year	cement fully energy consumption (kgce/t)	clinker fully energy consumption (kgce/t)	total energy consumption and percentage in the national total, (Mt energy coal)
2001	/	157	/
2002	/	162	83 (5.2%)
2003	/	159	93 (5.0%)
2004	/	156	109 (5.1%)
2005	127	148	117 (5.0%)
2006	120	142	131 (5.1%)
2007	115	138	142 (5.1%)
2008	104	130	145 (5.0%)
2009	95	122	150 (4.9%)
2010	93	115	165 (5.1%)

3) Nonferrous Metallurgy

According to the network information provided by China's Energy Conservation Online in 2011, the energy consumption of nonferrous metal industry in China in 2005 attained to 83.41 million tons energy coal, which accounted for about 3.8% of the national total energy consumption of the year. In all the nonferrous branch the production of electrolyzing aluminum and aluminum oxide is the first major energy consumer, not only because of the its high energy need per capita but also of its large yield. In 2006, the national yield of aluminum oxide was 13.7 million tons of alumina and 8.15 million tons of aluminum materials. The energy consumed by the whole aluminum industry accounted for about 75% of the non-ferrous metal industry. Apart from the aluminum branch, the production of zinc ranked the second. In 2006, the yield of zinc in China was 3.153 million tons, and consumed 9946 million kWh, which is equivalent to 4.02 million tons of energy coal. To 2009, the

whole national yield of the ten non-ferrous metals (copper, aluminum, lead, zinc, nickel, tin, antimony, magnesium, titanium sponge, mercury) reached 26.05 million tons, with 4% of year-on-year growth. This nonferrous metal yield consumed 83.14 million tons of energy coal, and took a proportion of 2.7% in the national total amount of energy of the year (See the reference Network News, Asian Metal Website, 2010. 3. 18.).

As showed in Table 7, the fully energy consumption for the main varieties of non-ferrous metal are all declining in the past ten years. However, as contrasts to the international advanced level, there still exist potentials for us to dig out. The official statistical data revealed that in 2006 the DC power consumption of the electrolyzing aluminum in China was 13506 kWh/ton, and the international advanced level is 13350 kWh/ton. The average energy consumption per capita for copper flash furnace smelting in China was 595 kgec/ton, and the international advanced level is only 500 kgec/ton.

TABLE 7 FULLY ENERGY CONSUMPTION OF MAIN NON-FERROUS METAL IN CHINA (kgec/t)

year	copper smelting	aluminum oxide	aluminum ingot	zinc smelting	zinc electrolyzing	tin smelting	antimony smelting
2001	1079.5	1180.0	6250.0	685.4	2050.2	2489.3	2294.8
2005	733.1	998.2	5888.3	654.6	1953.1	2444.6	1646.3
2008	429.8	817.0	5786.5	472.9	973.9	2451.6	1110.0

Data Source: The Development Report of China Energy Conservation and Emission Reduction in 2009 , Beijing:Water Power Publishing House,2012.

TABLE 8 INTERNATIONAL COMPARISON BETWEEN THE CHINA'S MAIN INDUSTRIAL PRODUCTS' ENERGY CONSUMPTION TO THE INTERNATIONAL ADVANCED LEVEL

product variety	2000			2009		
	China	International	Difference(%)	China	International	Difference(%)
Net Coal Consumption Rate for Fossil-fired Power Plant (gce/kW.h)	392	316 (Japan)	24.1	340	307 (Japan)	10.7
Comparable Energy Consumption for Steel (kgce/t)	784	646 (Japan)	21.4	679	612 (Japan)	10.9
Fully Energy Consumption for Cement (kgce/t)	181	126 (Japan)	43.7	151*	123* (Japan)	22.8
Fully Energy Consumption for Ethylene (kgce/t)	1125	714 (Middle-East region)	57.6	950**	629** (Middle-East region)	51.0
Fully Energy Consumption for Sythetic Ammonia (kgce/t)	1327	970(US)	36.8	1300	970(US)	34.0
Full Energy Consumption for Paper and Paperboard (kW.h/t)	1540	678 (Japan)	127.1	1090	580 (Japan)	87.9

* data in 2008. ** data in 2010.

Data souece: (1) China Energy Statistical Yearbook 2011, (2) Wang Q Y,2006

International Comparison of the Sub-divisional Energy Consumption

Energy consumption per capita product reflects the general level of the enterprise's technology and management, and is usually used as the basis for the cost accounting. In Table 8 China's energy consumptions per capita of the typical industrial products in 2000 and 2009 are presented with the comparison of the advanced level international. It is clear that all products had reduced their energy consumption after nine years, and the relative difference with the international advanced level diminished. Nevertheless, the energy consumption for the ethylene and for the paper still remains over 50% difference higher than the international best level.

There is still a long way for those industries to reach the energy-conservative production goal.

On the other hand, the Energy Efficiency can be also adopted to indicate the general efficiency in a county or a department. The energy efficiency is defined as

the national total energy consumption over the GDP in the same period. For the main nations of the world the energy efficiency in the past decades is showed in Table 9. Obviously, the China's energy efficiency has ever been higher than those developed countries. Only India's in the table was higher after 2008 than China. Nevertheless, due to the continual effort by the Chinese government and the enterprises during the past decades, the energy efficiency in China has greatly decreased. Today, the Chinese government still commits to the implementation of the energy conservation and industry structure-reforming policy. In addition, by the report of Tengxun Financial Network(<http://finance.qq.com>), in 2011 the energy efficiency of China had dropped to 4.98 ton energy coal / ten thousand dollars. However, as the world's second largest economy country, China must persist in the strict national energy policy for many years so that the development of the economy is sustainable. A lot of problems related to the energy need the government to take effort to deal with.

TABLE 9 THE ENERGY EFFICIENCY COMPARISON OF MAIN COUNTRIES (ton energy coal / ten thousand dollars)

Country	1990	2000	2005	2007	2008	2009	2010
China	27.653	12.143	10.456	8.002	6.430	6.152	5.528
U.S.	4.837	3.386	2.681	2.204	2.305	2.206	2.217
Japan	2.117	1.617	1.663	1.711	1.475	1.355	1.318
India	14.510	14.449	9.344	7.037	7.414	7.502	7.590
Germany	2.981	2.581	1.767	1.452	1.331	1.384	1.454
Brazil	4.415	4.267	3.561	1.680	2.219	2.230	1.844

Data source: International Statistical Yearbook 2011

China's Energy Strategy of Development in the Future

In 2004, the Joint Research Center of European Commission (JRC) issued the predicted trend of world's energy structure for the 21st century (Li J. F. et al, 2008), see Figure 3. Before 2050, the fossil energy such as coal, oil and natural gas, will keep the leading role in the energy structure, while the renewable energy will rise up rapidly and take more and more proportion. To 2050, the fossil energy and renewable energy may be of equal shares. In the end of the century the renewable varieties are supposed to play the main role in the world's energy structure.

The change of world's energy structure is bound to affect the China's energy strategy and policy. The data presented in this paper are already quite different compared to those in a literature written by the current author eight years ago (Yuan Z. X., 2005). In order to adapt to the change of the world's energy pattern, in the past years Chinese government has made out systematic energy strategy of development. In 2004 the State Council of China formulated the Medium and Long Term Development Plan of Energy (2004 -- 2020), and issued the strategy of vigorously adjusting and optimizing the energy structure—adhering to taking the coal as the main energy body, developing the electric power in large scale, pushing

the oil, the gas and the renewable energy to wide application and etc. The energy conservation is the first important. By implementing strict energy-conservative system and measures, the efficiency of energy utilization is expected to improve significantly. It is also emphasized relying on the scientific progress, extensively taking advantage of the new technology, eliminating the outdated facilities and process, and strengthening the scientific management. The carrying capacity of the resources and environment must be taken fully into consideration, and the impact to the environment from the energy production and consumption must be reduced largely. With these policies and measures an energy-efficient economy and society is realized finally.

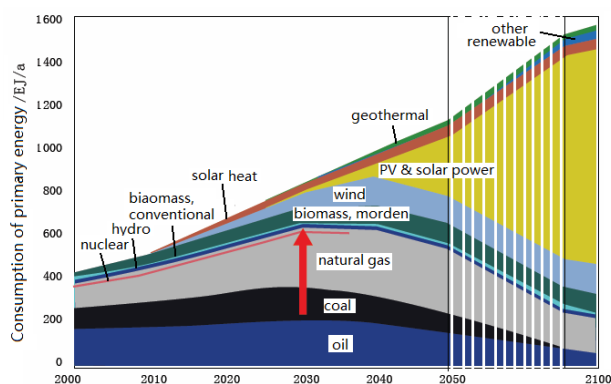


FIG. 3 PREDICTED CHANGING TREND OF WORLD'S ENERGY STRUCTURE IN 21ST CENTURY, BY THE JOINT RESEARCH CENTER OF EUROPEAN COMMISSION

During the period of the 11th Five-Year Plan, China's achievements of energy conservation and emission reduction drew the worldwide attention. In this period China's annual GDP grew at the rate of 11.4% increment, while the annual energy consumption in average only grew at the rate of 6.8%. This means that China has less consumed 4.9 hundred million tons of energy coal and reduced of 11.3 hundred million tons of carbon dioxide emissions than what expected. The national emission reduction target has been successfully completed. Entering the 12th Five-Year Plan period, China will stride forward from a middle-income country to a middle-developed country. With the accelerating process of industrialization and urbanization, the energy demanded will be in rigid growth. In addition to the constraints of the resource and the environment, the traditional economic growth pattern is facing new challenges. To realize China's government's goal that the carbon dioxide emission per unit GDP in 2020 decreases by 40% - 45% than that in 2006, great efforts are needed. Both the growth rate of the energy consumption and the energy structure

will change markedly. The traditional mode that extensive energy supply meets the fast economic demand will weaken, and the mode that the reasonable demand to the energy is guaranteed by the scientific supply will be strengthened. According to the "12th Five-Year Plan", non-fossil energy will take 11.4% of the whole primary energy consumption, and the energy consumption per unit GDP will reduce by 16%. The supporting measures are: Adhering to the conservation priority, basing on the domestic resources, emphasizing diversified energy varieties and environment friendly. The international cooperation of mutual benefit is important. Adjusting and optimizing the energy structure is obligatory. Upon the ensured safety, the development of the nuclear power is necessary. We also need to push forward the efficient use of the wind, the solar, the biomass, the geothermal and the other renewable energy forms. The application of distributed energy system must be paid enough attention, too.

Conclusion

Energy is always a hot topic in the scope of world. In the past decade China's energy consumption has been increasing and will maintain a high growth rate in the upcoming decade. The security of the energy supply has become an important problem that limits the sustainable development of China's economy. Therefore, we must strengthen the work of the industrial energy conservation, especially for those leading energy-consuming branches such as iron and steel, non-ferrous metal metallurgy, chemical engineering, electricity power generation, and building materials. On the other hand, we must conduct strictly the policy of adjusting the industrial structure, reducing the proportion of the high energy-consuming branches in the whole industry. At the same time, we also need to invoke the advanced technology around the world to make full use of the clean energy, so that the direct use of the coal is reduced gradually. It is advocated using the coal for power generation, as well as the coal gasification and liquefaction. With more and more utilization of the wind, the solar, the biomass, the geothermal, the hydraulic, and the other renewable energy, China is expected to switch the pattern of the energy consumption to a healthier road in the 21st century.

ACKNOWLEDGMENT

This work was sponsored by the National Natural Science Foundation of China - (No. 51276005)

REFERENCES

- BP World Energy Statistics Yearbook [M],2011
- China Energy Statistical Yearbook 2011 [M],Beijing:China Statistics Press,2012.
- China Energy Statistical Yearbook,7-2 subsection,the Total Energy Consumption and Its Constitution, [M], Beijing: China Statistics Press,2010.
- International Statistical Yearbook 2011[M],Beijing:China Financial and Economic Publishing House,2012.
- Jiang M L,Status of the Energy Consumption and Pathways of the Energy Conservation for Chinese Cement Industry [J],Cement Guide for New Century,2007,(5):1-4
- Li J F, Wang S C, Zhang M J, Ma L J, China Solar PV Report 2007, China Environmental Science Press, 2008.
- Network News,Energy Consumption Status and Conservation Measures of Non-Ferrous Metal [R],China's Energy Conservation Online, www.Cecol.com.cn,Jie-Neng-Kong-Jian>>Gong-Ye-Neng-Hao-Jie-Neng >>You-Se-Jin-Shu, 2011. 12. 27.
- Network News,Production Rose and Energy Consumption Decreased in China's Nonferrous Metal Industrial in Last Year [R],Asian Metal Website ,www.asianmetal.cn,2010. 3. 18.
- The Development Report of China Energy Conservation and Emission Reduction in 2009 [M],Compiled By China Energy Conservation Investment Corporation,Beijing: Water Power Publishing House,2012.
- The Joint Statistical Manual of the BRIC countries [M],Beijing:China Statistics Press,2012.
- The Union of Supervising Quantity and Economy in China's Building Materials Industry, Review on Energy Utilization of Cement Industry During the National 11th Five-Year Plan [J],China Cement,2011,(1):30-35
- Wang Q Y,International Comparison and Its Enlightenment of the Energy Consumption Per Unit for the high Energy-Consumed Products in China,International Petroleum Economics,2006(2):24-30.
- Wang T C,Zhang Y Y,Chi J D,Analysis of China's Energy Conservation in Iron and Steel Industry [R],China's Steel Industry,2007,(3):20-24.
- Wang W X,Current Situation and Potential Analysis of Energy Conservation of China's Iron and Steel Industry [R],www.doc88.com,Industry data >>Iron and steel metallurgy,2010. 12. 19.
- Yuan Z X,China's Energy Conditions and Development Strategies,China Metallurgy,2005,15(5):7-9
- Zeng X M,The Cement is the Model Industry of Building a Low Carbon Industry Chain of Energy Conservation and of Emission Reduction.[R],Western Cement Website, www.xbsn.com,2011. 8. 9.